**“BABEŞ-BOLYAI” UNIVERSITY**
**CLUJ-NAPOCA**
**FACULTY OF HISTORY AND PHILOSOPHY**
**DOCTORAL SCHOOL OF HISTORY, CIVILIZATION, CULTURE**

# *Materials and construction techniques used in order to build structures on stone phases of Colonia Ulpia Traiana Augusta Dacica Sarmizegetusa*

## ABSTRACT

**PhD Coordinator:**

**Prof.Univ. Dr. Ioan Piso**

**PhD Student:**

**Barbu Marius Gheorghe**

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# SUMMARY

## Part II

**Key concepts:** Antiquity, the Roman Empire, builders and architects, tools and utensils used in building processes, building materials, stone, tegular materials, Roman binder, construction techniques, arches and vaults, architectural orders, the Dacia region, the Dacian Colony of Sarmizegetusa, raw materials, binder analysis, *opus quadratum, opus incertum* or *opus mixtum, Forum Vetus, Capitol,* the dwellings from the *Island 3* division.

**Abstract:** The purpose of this thesis, dedicated to the Roman building techniques used at Ulpia Traiana Sarmizegetusa, is to foray the analysis of the building methods and materials used in the Roman world and their application in the case of the buildings from the stone periods of Dacia's capital.

The work consists of two distinct parts, also structured in chapters, subchapters and points. The first part deals with the materials, operating methods and building techniques used by the Roman architects and builders. To start with, problems concerning the Roman builders' statute and the category of craftsmen involved in such activities were brought into light. Furthermore, the tools and utensils used by them, in different stages and aspects of completing a building, were reviewed.

A major part of this work is dedicated to the analysis of the materials and raw materials used in the Roman building systems. Therefore, the extraction, cutting and handling the rocks, the fabrication and utility of the tegular materials or the importance and impact of diversifying the use of binder in the Roman architecture are dealt with. Nevertheless, other building materials, easy to overlook during archaeological research, such as wood, glass or metals, weren't forgotten.

The most significant chapter of the first part concerns the analysis of the structural parts of the Roman buildings and the building styles and techniques used by the Romans in building them. The major theme of the first subchapter is the execution of the foundations and substructures of the Roman edifices, followed by another subchapter, which analyses the methods of walls edification, their type and condition. Herewith, the Roman construction works (*opus*) were treated, by describing the assembling methods of the types of walls with the greatest usage in the Roman architecture (*opus siliceum, opus quadratum, opus caementicium, opus incertum, opus reticulatum, opus quasi-reticulatum, opus letericium, opus testaceum, opus vittatum or opus mixtum*).

The next subchapter renders the studies carried through with regards to the typology, evolution, embodiment and way of execution of the arches and vaults, as extremely important building elements, characteristic of Roman edifices.

Although this thesis is not an architectural study, the apposition of building techniques and architectonic executions triggered the existence of a subchapter dedicated to describing the architectural orders borrowed by the Romans from the Greek architecture. This is accomplished in the outlook of analyzing the discontinuous vertical frames, most relevantly represented by the component elements of the colonnades. Thus, the column components, but also the components of the entablements sustained by them, are described, as well as the most important characteristics of the classic architectural orders, Doric, Ionic and Corinthian.

Not lastly, other building elements, such as different types of boards and floors, roofs or coatings, are reviewed.

The second part of the paper begins with a chapter dedicated to a short description of the Ulpia Traiana Augusta Dacica Sarmizegetusa Colony and to a history of the research undertaken throughout the time in this settlement.

The next chapter treats the building materials existent at Ulpia Traiana Sarmizegetusa. The sources and quarries of obtaining different types of rocks existent in the walls of the buildings here were debated, but also the stone workshops discovered throughout the colony. Moreover, the output of tegular materials, produced at Sarmizegetusa, as well as their typology and characteristics are discussed. A very interesting subchapter is the one that describes the results of the analysis performed on a binder sample, undertaken from different edifices of the ancient city.

The last chapter embodies the analysis of the local putting into effect of different Roman building techniques, the last part of the thesis consisting of several case studies which analyze the building techniques used by the builders from Sarmizegetusa in order to build-up some constructions and structures, such as Trajan's Forum, the Capitol or different civil dwellings.

The building materials and techniques used during the works of structures building-up in the stone period of the Dacian Sarmizegetusa Colony were very diversified, generally reflecting a correlation with the aspects encountered in other parts of the Roman Empire.

As far as the building materials used are concerned, we can observe the pragmatism of the Roman builders from Sarmizegetusa, who have chosen to use, most of the times, local raw materials, easy to acquire and, obviously, cheaper. The fact that the greatest majority of walls consists of river rocks is to be remarked. Quarry stones were also exploited, especially the

ones belonging to the neighbouring areas, walls such as those from the Ancient Forum, from the *horeum*, or from civil dwellings, constructed with irregular pieces of local mica-schist. The same mica-schist, but also local floor tile, were exploited due to their properties to disbranch in large-sized, but thin platens, this type of slabs being extremely useful for paving the roads or covering the big drainages, as well as for coating some walls, such as the ones from the entrance of the dungeon from under the East courthouse of the Ancient Forum.

Local floor tile was also used for cutting the blocks used for building the walls from the city premises, this work representing probably the greatest building effort of the settlement here, taking into consideration the size of the fortification perimeter and the building technique used. Most probably this effort is the reason for which the usage of floor tile blocks was preferred to the detriment of chalkstone blocks, used for building other types of edifices, such as the *basilica* or the Ancient Forum. The floor tile had the advantage of being easily processed and especially of being found in the vicinity of the city, the transport of raw materials representing a very important factor in the economy of building development, as we find out from the ancient authors' statements. The chalkstone blocks, more solid than the floor tiles blocks, were used in the beginning for the realization of the superb *basilica* and thereafter, sometime during the midpoint of the second century, for the realization of the stereobates and most probably of the Capitol walls. The transportation of the chalkstone from Sântămăria de Piatră required a greater effort, this raw material being chosen due to its superior qualities and being used for building some superb public edifices, one more reason for choosing this quarry being that chalkstone exploitations were carried out on the Valley of Strei ever since the times of the Dacian Kingdom.

Instead, a new source of raw materials was the marble quarry from Bucova. Whereas this marble was erratically used since the beginning of the second century AD, as in the case of the *gromae* base from the crossroads of the main streets of the city, the intense exploitation and its solid usage within the Sarmizegetusa buildings took place several decades later, in the second half of the second century and during the following century, the capital of the Dacia region becoming a city, whose public edifices were built or massively plated with white marble. The rocks from greater distances, such as the andesite brought from the Valley of Mureş, were used especially for manufacturing some elements that lent themselves to being made of this type of rocks.

The only building material brought from outside Dacia's borders seems to be the multicoloured marble, used for building the pavement of the Capitol's navar, the usage of a

rock which most probably originates from the coasts of Turkey proves the importance of this edifice, at Sarmizegetusa.

The tegular materials present themselves in a great variety of forms. The huge number of stoves used to burn these building materials, as well as the impressive diversity of producer's stamps discovered in this area make Sarmizegetusa an important centre of production for these materials. The output of tegular materials in the capital of the Dacian region was definitely highly important, but it needs to be related with the great demand of a settlement of such proportions. Although almost all the types of fictile materials (bricks, roof tiles, ridge-tiles, antefixes, hypocaust cells, heating tubes, pipelines for water hauling, paving elements) were discovered, we may claim that, at least in the first decades of the city's existence, the production leant mainly towards the elements destined for building roofs and hypocaust systems. The relative deficiency of specific building up bricks is also certified by the usage of replacing tegular materials in the realization of some of the works. For example, bipedal bricks, specific to the heating systems' support, seem to have been used in the case of the dungeon vault from under the east courthouse. Likewise, one of the drainage eyeholes from the north culvert of *decumanus maximus* towards the sewer underneath it was made of roof tiles.

The general aspect of most of the walls also certifies the fact that, although within the Empire the brick represented an extremely utilized building material during the second and the third century AD, within the capital of the Dacia region they were infrequently used. There are few cases that could be identified in which the bricks were actually used for building up, the percentage appearing to rise a little towards the end of the second century, when bricks were used for creating the pattens in some apsides built in the north-east and north-west corners of the Ancient Forum.

The analysis carried out on some binder samples also determined drawing some conclusions. The optical microscopy shows that lime and/or anhydrous lime, present all through the binder, had been recarbonated. This fact is highlighted by the presence of the calcite layer within the walls from inside the pinholes. The drawn conclusion was that as far as the quantities of sand and lime used are concerned, the proportions indicated by the ancient authors were kept to, fact that didn't always happen, Plinius claiming that this insufficiency was the main cause of the demolition of Rome's buildings. A proportion of one third lime and two thirds sand was used for the binder with which the Great Temple, as well as the dwellings' walls from the "*Island 3*" division were built, following Vitruvius's recommendation for the cases in which the composite contains river sand.

The *opus signinum* sample taken from the hypocaust pavement from *schola gladiatorum* indicates a similar proportion of lime, with the mention that in this case the aggregate consists of sand mixed with chapped shards, which have created extremely strong chemical bonds around them.

The binder used for coating the collectors of the Financial Procurator residence's bathrooms had an increased lime concentration, namely two fifths, the fact that the ceramic addition subsisted in a powder with thin granulation being also observed.

Therefore, the chemical composition of these binders differed according to the nature of the achieved objective.

From the point of view of the building techniques used, they were chosen dependent on the future edifices' destination and characteristics, but also on the character of the available building materials.

Analyzing the case of the *opus quadratum* constructions researched up until now at Sarmizegetusa, it can be ascertained that most of them are edifices of public interest. Hence, we can claim that the constructive effort to build edifices out of massive stone blocks was channeled towards the big city monuments, the buildings that hosted the centre of political, administrative, economic and religious activities of the community, but also towards the defense system of the colony, an extremely important system for the lives of all the inhabitants.

The only buildings of private interest completed in *opus quadratum* are two funeral edifices (the Mausoleum Aurelia and the Mausoleum of the Drajcov Valley). Despite the fact that the workload and the volume of raw material cannot be compared to the ones in the case of the great public edifices, the fact that certain members of the Ulpian community could afford to build grand funeral monuments reflects the existence of a wealthy social class, capable of meaningful financial efforts.

From a typological point of view, the *opus quadratum* buildings raised at Sarmizegetusa comes under the working technique that is characteristic of the first century's ending and of the second century AD, when the structures made of ashlar combine with segments made of rough stones or bricks and binder. All the analyzed buildings have foundations carried through in *opus caementicium*, in most of the cases even the patten combining either with this technique, or with *opus incertum*.

With regards to chronology, a differentiation between the building manners for the periods when Dacia was an integrated part of the Roman Empire cannot be outlined, as the multiangular disposal of the elements didn't show signs of considerable evolution. Thus, at

Sarmizegetusa there were buildings raised from wrought blocks of stone, both in the first decades of the second century AD and towards its end and the beginning of the following century.

The minor flat disposal of the elements displays interesting characteristics, the walls built in this manner at Sarmizegetusa having a different appearance from their equivalents belonging to other regions of the Empire. Whereas in the Italic Peninsula and in the occidental region the building manner specific to the princedom period is the so-called *opus mixtum*, at Sarmizegetusa we can notice that the alternation of stone layers with brick layers is very seldom used and if it is, the percentage of bricks is by far inferior to the percentage of stones. Hence, the brick layers are rare and thin, having, from a technical point of view, the role of equalizing and connecting the walls' structure. This structure strengthening role, through the insertion of brick layers, is materialized at Sarmizegetusa by the insertion of some local mica-schist layer in the walls made of river stone. By means of this artifice, the local builders manage to keep up with the building techniques used in the other parts of the Empire, in a cheap-as-possible way. The stone layers successfully replace the bricks, even when dealing with pretentious structures, such as the vaults covering the subterranean rooms from under the *curia*. These vaults contain only two allotments of three brick layers each that have a shape predestined for manufacturing arches, the rest of these structures' frame being assembled from the above-mentioned layers.

At Sarmizegetusa there were also recorded almost all the types of techniques, used for obtaining pavements or for planishing the walls of the buildings in the Roman period. There are recordings of hypocaust systems, painted coatings, marble plies for the walls, stone pavements, simple binder or *opus signinum*, pavements made of ceramic elements or mosaic and so forth.

With regards to the three case studies analyzed at the end of the thesis, they were conclusive for the probation of the fact that the building materials and techniques used at Sarmizegetusa had different roots, according not only to the chronological period, but especially to the edifices' character.

The Ancient Forum of the first Dacian colony constituted the centre of the public, administrative, politic and economic life of the Sarmizegetusa citizens. It consists of edifices that are built in various manners and using different materials, which confers an impact image on the viewers. It is remarked that the perspective points such as the monumental entrance or the *basilica* are made up of large chalkstone blocks, which increases the visual impact, whereas the less visible areas are made of irregular stone and binder. The aspect of this centre

becomes even more spectacular with its marbling, which took place in the second half of the second century AD.

The case of the Capitol is relevant for exemplifying the building patterns used within some monumental edifices such as this one. Its foundation was built in *opus caementicium* in the areas from under the supporting structure and in the filling areas it was made of clay and stone, fact that brings into light again the pragmatism of the builders from Sarmizegetusa, even if this thing deviates from Vitruvius' precepts. Conversely, the podium structure accurately follows all these precepts, being made of solid stereobates, chalkstone blocks and well-battered filling areas. The patten itself, though destroyed by modern intervention, could be rebuilt conceptually, as being a Corinthian temple with six columns in the front, *peripteros sine postico*. This temple, which possessed an important role in the religious life of the town's citizens, as well as in the entire region, was plated with marble, from the same Bucova rock that the superb colonnade and the 4.50-metres-high cult statue were made of. The proof of this monument's importance is the fact that the navar pavement was made of polychromatic marble plate, brought from a considerable distance, from the quarries in Asia Minor, which also gave the precious material for embellishing some monumental edifices in Rome.

The research of several dwelling segments located in the islands from the west side of the Ancient Forum led to drawing some important conclusions, such as the fact that at some point in the past there were performed extensive urbanistic works that changed the image of this side of the city, through the demolition of civil buildings and their replacement with an edifice whose walls impress through their sizes.

# BIBLIOGRAPHY


J-P. Adam, *La construction romaine materiaux et techniques*, Grands Manuels Picard, 1984.

D. Alicu, C. Pop, V. Cătinaş, *Ateliere de pietrărie la Ulpia Traiana Sarmizegetusa*, în *AMN*, 13, 1976, pp. 125-140.

D. Alicu, *Tehnici de construcție la Ulpia Traiana Sarmizegetusa*, în *AMN*, XVII, 1980, pp. 447-461.

D. Alicu, *Instalații de hypocaustum la Sarmizegetusa*, în *AMN*, XVIII, 1981, pp. 425-435.

D. Alicu, *Două cuptoare de ars țigle şi cărămizi de la Ulpia Traiana Sarmizegetusa*, în *AMN*, 21, 1984, pp. 467-475.

R. Ardevan, *Le collège des fabres à Ulpia Traiana Sarmizegetusa*, în *AMN*, XV, 1978, pp. 167-172.

R. Ardevan, *Patronii Coloniei Ulpia Traiana Sarmizegetusa*, în *Sargetia*, XIV, 1979, pp. 185-190.

R. Ardevan, *Mozaicurile Sarmizegetusei şi cărturarii români la 1825*, în *Marisia*, 11-12, 1981-1982, pp. 99-104.

G. Băeştean, *Aprovizionarea cu apă în Dacia romană*, Cluj-Napoca, 2008.

G. Băeştean, T. Albulescu, *Monografie istorico-etnografică a localității Sarmizegetusa*, 2012.

M. Bărbulescu, *Interferențe spirituale în Dacia Romană*, Cluj-Napoca, 2003.

M. Benea, M. Gorea, N. Har, *Materiale tegulare romane de la Sarmizegetusa (1). Caracteristici mineralologice şi fizice. Tegular Materials from Sarmizegetusa (1). Mineralogical and Physical Characteristics*, în *Revista Română de Materiale*, 2007, 37 (2), pp. 122 – 129.

T. F. C. Blagg, *Tools and Techniques of the Roman Stonemason in Britain*, în *Britannia*, Vol. 7, 1976, pp. 152-172.

N. Branga, *Urbanismul Daciei romane, Timişoara*, 1980.

G. Brodribb, *Roman brick and title: an analytical survey and corpus of surviving examples*, Great Britan, 1987.

C. Daicoviciu, *Sarmizegetusa (Ulpia Traiana) în lumina săpăturilor. Les Fouilles de Sarmizegetusa (Ulpia Traiana)*, în *ACMIT*, 4, 1932-1938, pp. 353-410.

C. Daicoviciu, H. Daicoviciu, *Ulpia Traiana*, Bucureşti, 1962.

H. Daicoviciu, D. Alicu, *Colonia Ulpia Traiana Sarmizegetusa*, Bucureşti, 1984.

Al. Diaconescu, E. Bota, *La décoration architectonique et sculpturale du forum vetus de Sarmizegetusa: origine, évolution et chronologie* în *AMN*, 39-40, 2002-2003, pp. 155-197.

Al. Diaconescu, E. Bota, *Le forum de Trajan à Sarmizegetusa. Architecture et sculpture*, Cluj-Napoca, 2009.

R. Étienne, I. Piso, Al. Diaconescu, *Les fouilles du forum vetus de Sarmizegetusa. Raport general*, în *AMN*, 39-40, 2002-2003, pp. 59-154.

C. Genestar , C. Pons, A. M´as, *Analytical characterisation of ancient mortars from the archaeological Roman city of Pollentia (Balearic Islands, Spain)*, Analytica Chimica Acta 557, 2006, pp. 373–379.

R. Ginouvès *et* R. Martin, *Dictionaire méthodique de l'architecture grecque et romaine,* Tome I, École Française d'Athène, École Française de Rome, 1985.

R. Ginouvès, *Dictionaire méthodique de l'architecture grecque et romaine,* Tome II, École Française d'Athène, École Française de Rome, 1992.

R. Ginouvès, *Dictionaire méthodique de l'architecture grecque et romaine,* Tome III, École Française d'Athène, École Française de Rome, 1998.

I. Glodariu, E. Pescaru, A. Rusu-Pescaru, Fl. Stănescu, *Sarmizegetusa Regia. Capitala Daciei preromane*, Deva, 1996.

P. Gros, *L' Architecture Romaine 2. Maisons, palais,villas et tombeaux*, Paris, 2001.

P. Gros, *L' Architecture Romaine 1. Les monuments publics*, Paris, 2002.

C. M. Harris, *Dictionary of Architecture and Construction*, McGraw Hill, 2006.

G. Lugli, *La Tecnica Edilizia Romana,* Vol. I, Roma, 1957.

C. Morales, *Libro De Arquitectura Tecnica Historia De La Construccion Roma*, Madrid, 2010.

I. Piso, Al. Diaconescu, *Forurile din Ulpia Traiana Sarmizegetusa*, în *AMN*, XII-XIII, 1985-1986, pp. 161-183.

I. Piso, *Fasti provinciae Daciae I. Die senatorischen Amtsträger*, Bonn, 1993.

I. Piso, *Le territorie de la Colonia Sarmizegetusa*, în *EN*, 5, 1995, pp. 63-82.

I. Piso, *Les estampilles tégulaires de Sarmizegetusa*, în *EN*, 6, 1996, pp. 153-199.

I, Piso, *Colonia Dacica Sarmizegetusa. I. Le Forum Vetus de Sarmizegetusa, I,* Ed. Academiei Române, Bucureşti, 2006.

I. Piso, F. Marcu, O. Țentea, G. Cupcea, R. Varga, *Das Kapitol von Sarmizegetusa*, în *Dacia*, N. S., LVI, 2012, pp. 119-123.

Gaius Plinius Secundus, *Naturalis historia*, 2004

F. Sear, *Roman Architecture*. Ithaca, New York: Cornell University Press, 1983.

A. Segal, Roman Cities in the Province of Arabia, in The Journal of the Society of Architectural Historians, Vol. 40, No. 2., 1981, pp. 108-121.

D. A. Silva, H. R. Wenk, P. J. M. Monteiro, *Comparative investigation of mortars from Roman Colosseum and cistern, Thermochimica Acta* 438, 2005, pp. 35–40.

A. Sinopoli, M. Basili, D. Esposito, *Construction techniques of Roman vaults and opus caementicium:The cases of Lupo and St. Gregory's Bridges*, în *ARCH'10 – 6th International Conference on Arch Bridges*, Fuzhou, China 2010, pp. 319-325.

A. Timofan, *Structura graecorum. Tehnici şi sisteme constructive la Histria în perioada greacă (secolele VII a. Chr. – I a. Chr.). Perpetuarea tradițiilor constructive greceşti în perioada romană timpurie (secolele I p. Chr. – III p. Chr.)*, 2011, Teză de doctorat.

Vitruvius, *Despre arhitectură*, Bucureşti, 1964.

V. Wollmann, *Cercetări privind carierele de piatră din Dacia Romană,* în *Sargeția*, X, Deva, 1973.

V. Wollmann, Mineritul metalifer,extragerea sării şi carierele de piatră în Dacia Romană, Cluj-Napoca, 1996.